The Virtual Human Program

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Non-Lethal Defense IV
Tyson's Corner, MD
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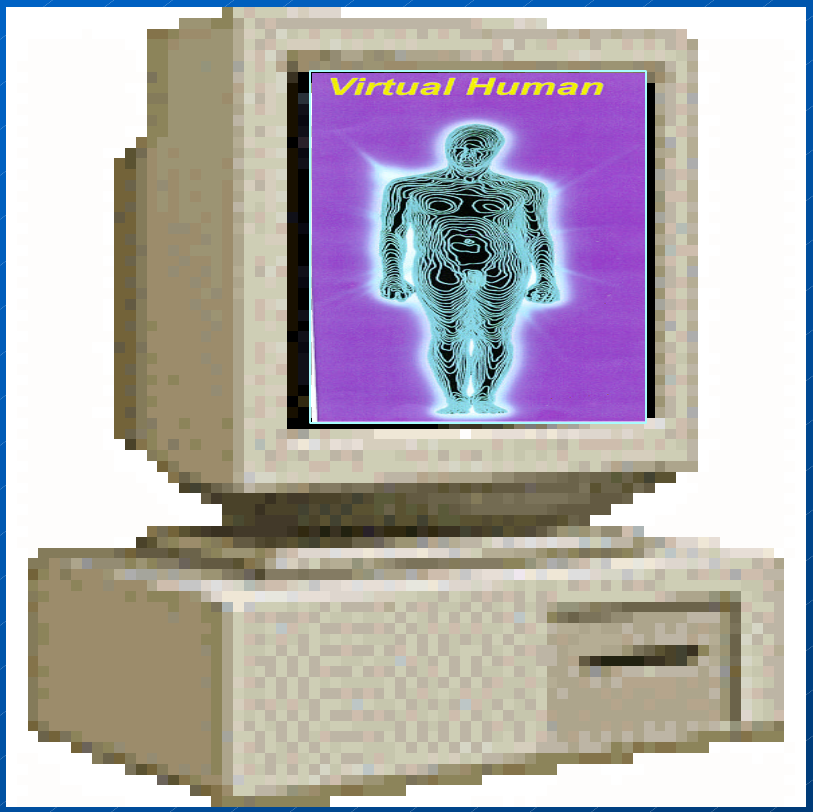
What was the Stimulus for the Origin of the Virtual Human?

Design a non-lethal, non-permanently injuring kinetic energy round for maximum effectiveness in changing a person's behavior (JNLWD, 1997)

- **Physics of round...relatively straightforward**
- **Impact on human**
  - **finite element analysis of round on tissue**
  - **non-linear tissue mechanics**
  - **physical response of affected organs**
  - **effects of endocrine system on damage, pain**
  - **psychological response to pain**

Vision



- **Model the Human**
- **Link Biology with Physics and Chemistry**

VISION (CONT'D)

- **Complete system consistent with current science (physiological and cognitive)**
- **Collaborators retain ownership of work**
- **Contribution from Oak Ridge National Laboratory**
  - **integration**
  - **specific modeling**
  - **instrumentation/data**

Functional Goals of 2005 Virtual Human

- **Scalable by age and gender**
- **All organs, full anatomy & physiology**
- **Limited pharmacokinetic capability**
- **Radiation & chemical risk**
- **Biophysical constants (tissue properties)**
- **Blood flow, breathing, endocrine, GI, renal, sensory, thermo-regulation, shock, limited brain function**

Functional Goals, Cont.

- **Specific disease information**
- **Duplicates physiology tests**
- **Incorporates certain patient-specific data**
- **Emphasize diagnostic assistance**
- **Fast forward capability**
- **Patient education & teaching tool**

APPLICATIONS OF MODEL:

- **Personal Virtual Model**
  - **Begin as infant**
  - **Appropriate Data from Parents**
  - **Personal Anatomic & Biochemical Data**
  - **Data Base “Grows” with Person**
  - **Genome Data Entered as Available**
  - **Provides the interface between the external environment and the genomic potential**

APPLICATIONS (CONT.)

- **Engineering and medicine interface: example of evacuation helicopter**

  -concern about effects of vibration

  -lack of controlled injuries, consent

  -wide range of amplitudes, frequencies

  -simulations with model to verify presence of real problem and validate solution

VIRTUAL HUMAN & BIOMEDICAL ENGINEERING AT ORNL

DOE " Improved Health and Environmental Quality"
Complex Biological Systems

ORNL: Complex Biological Systems,
Terascale Computing and Simulation Science

Science Base

Systems Biology
Biomedical Eng
Computational Sci
Information Sci
Analytical Sci
Systems Eng
Instrument Dev
Micro, Nano-Tech
Finite Element Mod
Distributed Systems
Dose/PBPK Modeling
Model Verification
Human Factors Eng

Applications

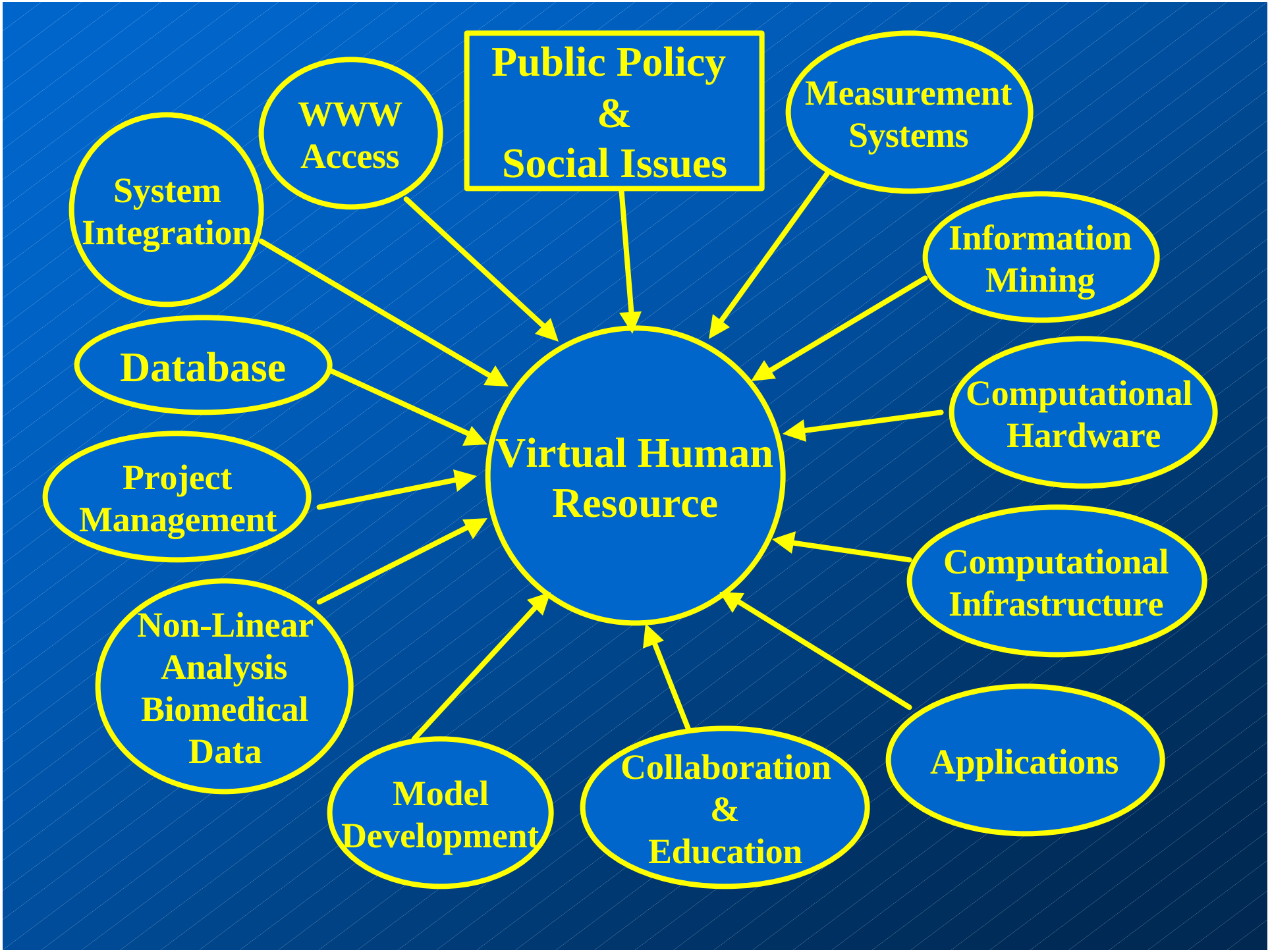
Medical Simulations
Occup & Env Health
Transportation Safety
Extreme Climate Simul
Human/Machine Inter
Training Simulation
Non-Lethal Force Model
Guide Diagnostics Dev
Assist Prosthetics Design
Weightlessness Sim
Simulate Treatment Alt
Forensic Modeling
Represent Bio/Phys Know
Health Science Education

Developing Partnerships

USAF Armstrong Lab
Walter Reed
PNNL
Boston University
University of Washington
Yale University
Vanderbilt University
University of Tennessee
Courant Institute
University of Alabama-B
Penn State University
University of Pennsylvania

In Addition

- **Long-term commitment (Institutional Memory)**
- **History of developing and operating "User Facilities"**
- **Ability to protect intellectual property of users**
- **Significant up-front investment**
- **Ability to compartmentalize work (Open, Proprietary, or Classified)**


Public Policy & Social Issues
WWW Access
Measurement Systems
System Integration
Information Mining
Database
Computational Hardware
Virtual Human Resource
Project Management
Computational Infrastructure
Non-Linear Analysis Biomedical Data
Model Development
Collaboration & Education
Applications

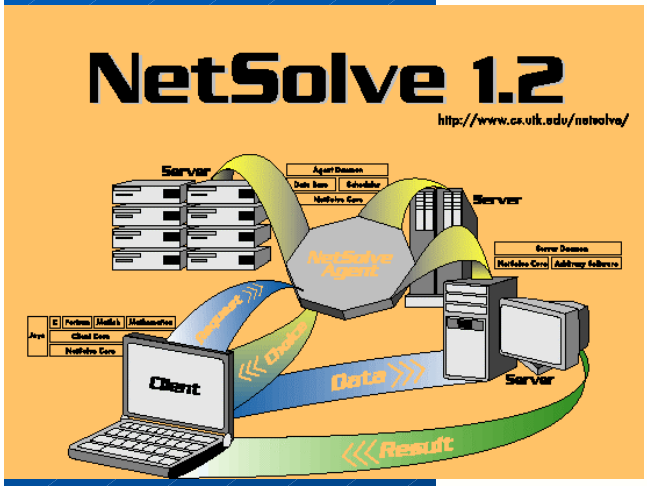
Computational Environment

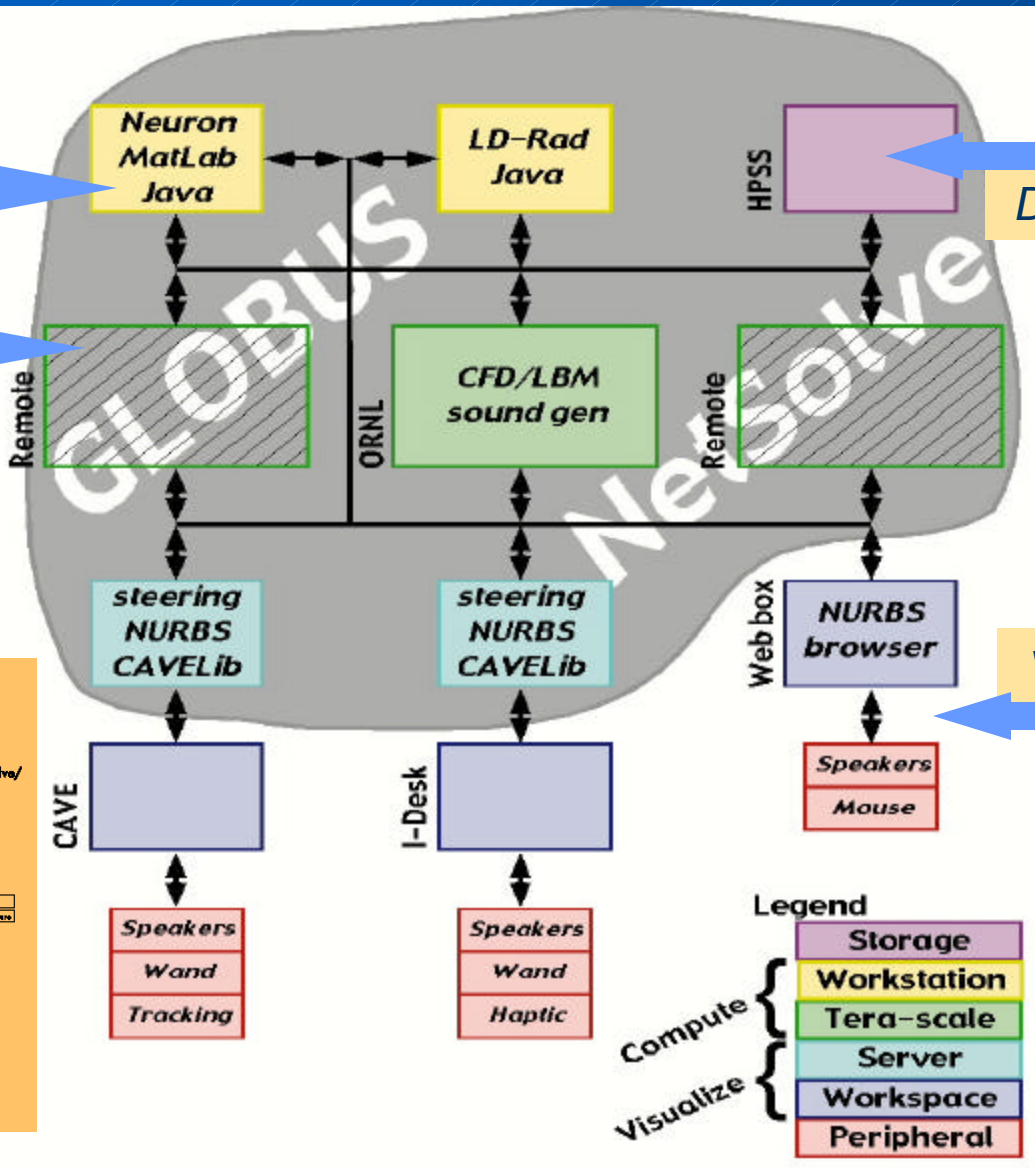
User Workstations

High-performance parallel computers

Data Storage

Visualization





Question: How will we get data for the Virtual Human?

- Advanced instrumentation capabilities: working with collaborative teams
- Injectable multifunctional sensors/advanced diagnostic approaches
- Exploit reading the “noise” in body signals
- Other advanced data acquisition and interpretation tools
- Ask what information is necessary not what can I get

Technology and Research Climate Now Available to Support Grand Challenge of Virtual Human Project

- Terascale (petascale) computing systems
- IT2 and beyond
- Measurement & analytical technologies
- Databases and data analysis tools
- Modeling environment…many contributors
- Focus on complex biological systems
- Agencies providing collaborative environment

Current Array of Information on Human Biology

- **Enormous resource available**
  - **existing models**
  - **information sources**
- **Challenge is to develop infrastructure and leverage this resource**
  - **make broadly known and accessible**
  - **develop methods and tools to integrate**
  - **new technologies to gather new data**

Historical Approach to Bewildering Array of Information

- Early naturalists provided infrastructure
- Taxonomy and classification
- Allowing integration of components into ordered assemblage
  - single animal
  - whole kingdom

ORNL's Vision of Virtual Human Initiative

Simulate human biology to advance our understanding of complex biological systems

- **Infrastructure (National Resource)**
  computational infrastructure to facilitate use of data and models
- **Integration**
  data and models

Virtual Human Initiative Meeting
National Academy, 28 Oct 1999

- 45 Attendees
- Presentations of vision by scientific panel
- Responses by agency representatives
- Conclusion: to request a report on the Virtual Human Initiative be prepared by the National Academy

Roadmapping Workshop
8-9 November 1999

Workshop Supported by the JNLWD

Diverse spectrum of participants

72 Total attendees

9 Agencies (23 individuals)

12 Universities (18 individuals)

5 National laboratories (17 individuals)

12 Private companies (15 individuals)

Conclusions of Roadmapping Workshop

- **Scientific consensus as to broad definition**
- **Consensus in planning process**
- **Broad support to participate in series of complex specific roadmapping efforts**
- **Agreement not to hype the Virtual Human Project**
- **Agreement that very specific plan needed to stimulate new national initiative**

Word of Caution

- Interagency collaboration required
- Exercise care in building expectations
- Significant planning effort required
- Focus for VHP must be much sharper
- Must provide evident value to communities of science, medicine, commerce, government, and public
- Precise technical execution of plan

What's Coming in the Near-Term?

- **Focused workshop early summer 2000**
  - **Kinetic energy effects**
  - **Current models**
  - **Active sources of data**
  - **Legacy models and data**
  - **Workshop designed to build data base**
- **Additional workshops in collaboration with TATRC and other collaborators**